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# Application of a Computer Model to Predict Optimum Slaughter End Points for Different Biological Types of Feeder Cattle

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**ABSTRACT:** A bioeconomic model was developed to predict slaughter end points of different genotypes of feeder cattle, where profit/rotation and profit/day were maximized. Growth, feed intake, and carcass weight and composition were simulated for 17 biological types of steers. Distribution of carcass weight and proportion in four USDA quality and five USDA yield grades were obtained from predicted carcass weights and composition. Average carcass value for each genotype was calculated from these distributions under four carcass pricing systems that varied from value determined on quality grade alone to value determined on yield grade alone. Under profitable market conditions, rotation length was shorter and carcass weights lighter when the producer's goal was maximum profit/day, compared with maximum profit/rotation. A carcass value system based on yield grade alone resulted in greater profit/rotation and in lighter and leaner carcasses than a system based on quality grade alone. High correlations (> .97) were obtained between breed profits obtained with different sets of input/output prices and carcass price discount weight ranges. This suggests that breed rankings on the basis of breed profits may not be sensitive to changes in input/output market prices. Steers that were on a grower-stocker system had leaner carcasses, heavier optimum carcass weights, greater profits, and less variation in optimum carcass weights between genotypes than steers that were started on a high-energy finishing diet at weaning. Overall results suggest that breed choices may change with different carcass grading and value systems and postweaning production systems. This model has potential to provide decision support in marketing fed cattle.

Key Words: Beef Cattle, Feedlots, Optimization, Models

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## Introduction

Beef is produced from cattle representing several breeds and breed crosses that are fed and marketed in groups or pens. Value of beef carcasses is determined by sex, age at slaughter, and carcass weight and composition. Breeds and breed crosses of beef cattle differ significantly in growth rate of fat, lean, and bone (Koch et al., 1976, 1979, 1982), and within a particular carcass grading system this results in different rates of change in carcass value as cattle are fed to heavier weights. Average value and costs associated with purchasing and feeding a group of cattle determine profitability within the feedlot sector of the beef industry. Amer et al. (1994a) showed that profit maximization was a more appropriate slaughter criterion for comparing beef genotypes than constant age, weight, or composition slaughter end points. Apart from comparing genotypes, methods to predict carcass value and production costs may also be of use to cattle feeders in making marketing decisions consistent with the goal of maximizing profit/head or profit/day. Our objective in this study was to develop a computerized system to predict input utilization and daily changes in average carcass value based on the USDA carcass grading system (USDA, 1987) of groups of feeder cattle grown under any postweaning production system and to integrate this system with an economic model to determine a slaughter end point that maximizes profit.

## Materials and Methods

Within a specific biological system defined by a particular set of input levels, total cost (**TC**) and total revenue (**TR**) are functions of the market price structure for inputs and output, and profit is the difference between TR and TC. Mathematical equations that represent input/output relationships are used to formulate models of biological systems. These models are valuable tools that may be used to investigate the impact of changes in input levels on

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output, and when combined with an economic model, inputs and output from biological models may be valued within any market input/output price structure to determine TR and TC. In the following sections we describe the economic and biological model used in this study and discuss methods used to cost inputs and value output predicted with the biological model.

### *Economic Model*

In the United States, beef cattle are finished on high-energy diets beginning at weaning or after a grower-stocker phase (backgrounding). Backgrounding systems may be characterized by duration of, and rate of gain during, the backgrounding phase; hence, it is theoretically possible that there is an infinite number of backgrounding systems. During the finishing phase cattle are fed and marketed in groups or pens, and these groups or pens are continuously replaced in time. The entire process of purchasing, finishing, and marketing a group of feeder cattle will be referred to as one rotation. This production process is very similar to asset replacement (i.e., a pen of feeder cattle may be considered as a asset to the cattle feeder that is continuously replaced in time). Perrin (1972) developed economic principles to determine optimal asset replacement strategies, and Melton (1980) used these principles to develop a continuous-time beef-cow culling and replacement model. The following notation and development of the economic model are taken from Perrin (1972):

$\rho$ = ln(1 + r); this is the interest rate that, when compounded continuously, results in an annual growth rate of r (i.e., $e^{\rho t} = [1 + r]^t$).
t = an integer number of years,
M(a) = the market (or salvage) value of the asset at age a,
R(a) = the flow of residual earnings (current revenues less current costs) from the process when the asset's age is a, and
C(b,s,m) = the present value of the stream of earnings of an asset that is purchased at age b and replaced at age s by a series of m identical assets. To simplify the notation (but without loss of generality) one can assume that the assets are acquired at age zero.

Present value of the stream of earnings associated with the first asset (for the feedlot, the first asset is the first rotation) alone is as follows:

$$C(0,s,1) = \int_0^s R(t)e^{-\rho t}\,dt + M(s)e^{-\rho s} - M(0) \qquad [1]$$

To determine the replacement age that maximizes the present value of the returns from just this first asset, the derivative of C(0,s,1) with respect to replacement age s is set equal to zero to obtain the following:

$$R(s) + M'(s) = \rho M(s) \qquad [2]$$

where

$$M'(s) = \partial M(s)/\partial s$$

According to Eq. [2] the value-maximizing replacement age s is the age at which marginal revenue (residual earnings plus changes in asset value) equals marginal opportunity cost (defined as the foregone interest that could be earned by selling the asset).

The other case considered by Perrin (1972) is one in which the asset manager wishes to maximize the present value of the entire stream of earnings $C(0,s,\infty)$ associated with an infinite number of assets that are continuously replaced in time, rather just the stream of earnings associated with the first asset. The present value of the entire stream of earnings is as follows:

$$C(0,s,\infty) = 1/(1 - e^{-\rho s}) \times C(0,s,1) \qquad [3]$$

To maximize this value with respect to replacement age s, its derivative is found and set equal to zero, to obtain the following:

$$R(s) + M'(s) = \rho M(s) + \rho C(0,s,\infty) \qquad [4]$$

The difference between Eq. [2] and [4] reflects the opportunity cost of postponing the earnings that will be realized from the next and subsequent assets. When future earnings are positive, the current asset will be replaced at an earlier age compared to Eq. [2], and at the same age when future earnings are zero.

The principles in Eq. [2] and [4] can be applied to a feedlot, where cattle feeders may want to maximize present value of profits associated with a single rotation, or the entire stream of profits associated with an infinite number of rotations. Time in a feedlot is measured in terms of days, and when days on feed and carcass weight increase, total cost increases at an increasing rate (daily cost increases), and total revenue increases at a decreasing rate (daily changes in carcass value decrease). These changes in total cost and total revenue are shown in Figure 1, along with total profit/rotation and profit/day curves for a single rotation over time in days. When profit/rotation is positive, profit/day is maximized at an earlier slaughter age than the slaughter age at which profit/rotation is maximized. Under both profit maximizing goals, slaughter age would be the same when profit/rotation is zero, and profit/day would be maximized at an older slaughter age when profit/rotation is negative.

Maximizing profit/day is the same as maximizing the present value of the entire stream of profits associated with an infinite number of rotations, and Eq. [2] and [4] can be used to obtain the average

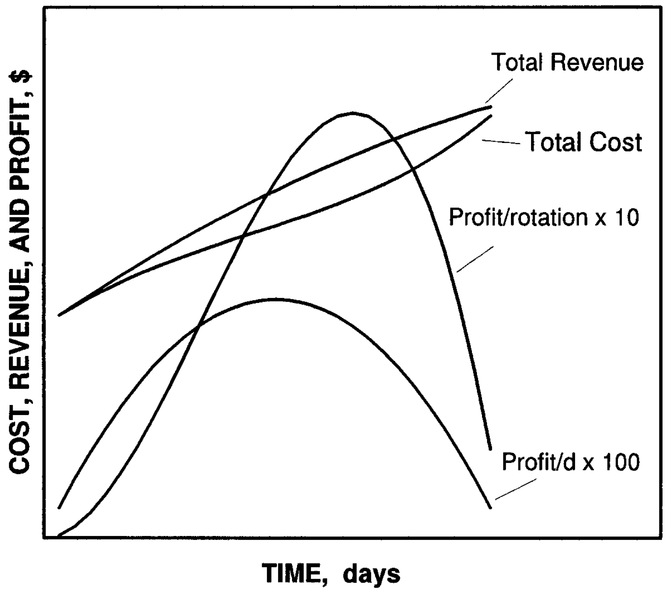


Figure 1. Present value of total revenues, total cost, total profit/rotation, and total profit/day for a single rotation over time in days.

slaughter age of a group of feeder cattle, under both profit maximizing goals with fixed input and output prices. In this situation R(s) would represent daily cost and be negative, M(s) would be average carcass value, M(0) would be purchase price of feeder cattle, and $\rho$ would be the daily discount rate. With these modifications Eq. [2] can be rewritten as follows:

$$M'(s) = -R(s) + \rho M(s) \qquad [5]$$

and Equation [4] can be rewritten as follows:

$$M'(s) = -R(s) + \rho M(s) + \rho C(0,s,\infty) \qquad [6]$$

Mathematical formulations in Eq. [5] and [6] were used to obtain slaughter ages that maximized present value of profit/rotation and profit/day, respectively.

*Biological Model, Animals, and Growth Rates*

Input utilization and output were simulated with a computer model developed by Keele et al. (1992). This model uses rate of empty BW gain (**dEBW**) as an input and predicts the amount of fat-free matter in dEBW (**dFFM**). Amount of fat in dEBW (**dFAT**) is obtained as dEBW – dFFM. Evaluation of the model with experimental data from a wide range of grower-stocker and calf finishing systems showed that it can accurately predict some of the effects of nutrition on body composition that were not associated with changes in EBW (Williams et al., 1992a). This model was used to simulate growth and body composition of 17 biological types of steers from birth to slaughter.

Steers were produced in the first three cycles of the Germ Plasm Evaluation (**GPE**) program from matings of Hereford, Angus, Jersey, South Devon, Limousin, Simmental, Charolais, Red Poll, Brown Swiss, Gelbvieh, Maine Anjou, Chianina, Brahman, Sahiwal, Pinzgauer, and Tarentaise sires to Hereford and Angus dams. Constant rates of growth were used from birth to weaning, and equations obtained from regressions of BW on linear and quadratic terms for days on feed (Smith et al., 1976; Cundiff et al., 1981, 1984) were used to estimate daily growth rates over the finishing period. Estimates of dEBW were obtained at birth and at weaning by multiplying BW at birth and at weaning by .956 and .86, respectively (Buckley, 1985). During the finishing phase, EBW was estimated from the ration composition and unshrunk BW according to Williams et al. (1992b). At birth the composition of EBW was set at 2.6% fat and 97.4% FFM (Buckley, 1985).

*Estimation of Average Carcass Value*

Under the USDA beef carcass grading system (USDA, 1987), carcasses of cattle aged 30 mo or less are described in terms of four quality grades (Prime, Choice, Select, Standard) and five yield grades (1, 2, 3, 4, 5). Cattle are fed in groups and at slaughter there is a distribution of carcasses and carcass weight within each quality and yield grade class. This distribution, along with the current market prices, determines the average carcass value (**ACVAL**) of the group, and total revenue is calculated as ACVAL times the group size. As cattle are fed to heavier weights toward the end of the feeding period, the distribution of carcasses and carcass weight within each quality and yield grade class changes, and these changes affect ACVAL. The following equation was used to calculate ACVAL of a group of feeder cattle:

$$ACVAL = \sum_{i=1}^{4} \sum_{j=1}^{5} CW_{ij} \times P_{ij} \times K_{ij} \qquad [7]$$

where $CW_{ij}$, $P_{ij}$, and $K_{ij}$ are carcass weight, market price/kilogram of carcass, and proportion of carcasses respectively, in the $i^{th}$ quality and $j^{th}$ yield grade class. The variables that need to be predicted are carcass weight (**CW**), yield grade (**YG**), and quality grade (**QG**). This information can then be used to estimate the distribution of carcasses and carcass weight in each quality and yield grade class, and a producer can use the current market prices with this distribution to calculate ACVAL as in Eq. [7].

*Estimation of Carcass Weight, Yield Grade, and Quality Grade.* The biological model is driven by EBW growth patterns and carcass weight was predicted from EBW with the following equation from Garrett and Hinman (1969):

$$CW = (EBW - 30.26)/1.362 \qquad [8]$$

In the model we assumed that the relationship in Eq. [8] was the same across breeds.

Continuous yield grade (**CYG**) was calculated with the following equation:

$$CYG = 2.5 + 2.5/25.4 \times BFAT + .2 \times KPHFP + .0038 \times 2.204 \times CW - .32/6.45 \times LMA$$

where BFAT is the thickness of external fat cover in millimeters over the longissimus muscle at the 12th rib, KPHFP is kidney, pelvic, and heart fat percentage, and LMA is surface area of the longissimus muscle in square centimeters.

Data on carcass composition of steers produced in the first three cycles of the GPE program at MARC were used to develop equations to predict BFAT, KPHFP, and LMA. These equations were as follows:

$$BFAT = CB_i \times CW^{.35} \times CFP^{1.92}$$
$$KPHFP = CK_i \times CW^{.01} \times CFP^{.86}$$
$$LMA = CR_i \times (CW \times (1 - CFP/100))^{.68}$$

where CW is carcass weight in kilograms from Eq. [8], CFP is carcass fat percentage, and $CB_i$, $CK_i$, and $CR_i$ are parameters for each trait specific to the $i^{th}$ breed. Values of these three breed parameters are given in Table 1. Predictions of empty body fat percentage (**EBFP**) from the biological model were used to calculate CFP with the following equation from Garrett and Hinman (1969):

$$CFP = (EBFP + .647)/.9246 \qquad [9]$$

In the model we assumed that the relationship in Eq. [9] was the same across breeds.

Qualification for a particular quality grade is determined by evaluation of the carcass class (steers, heifers, cows, bullocks, or bulls), maturity, degree of marbling (visible fat in the cross-section of the longissimus cut between the 12th and 13th ribs), and firmness of the lean, with maturity and marbling being the most important (USDA, 1987). We assumed that at slaughter steers would be less than 30 mo of age and used only degree of marbling to determine quality grade. Carcasses with devoid, practically devoid, and traces degrees of marbling are graded Standard, those with slight marbling are graded Select, those with small, modest, and moderate degrees of marbling are graded Choice, and those with slightly abundant, moderately abundant, and abundant degrees of marbling are graded Prime. Degree of marbling was determined by marbling score that is correlated with CFP. Marbling scores used in the GPE program were 24, 23, 22 = moderately abundant; 21, 20, 19 = slightly abundant; 18, 17, 16 = moderate; 15, 14, 13 = modest; 12, 11, 10 = small; 9, 8, 7 = slight; 6, 5, 4 = traces; 3, 2, 1 = practically devoid. Carcass compositional data of steers produced in the first three cycles of the GPE program at MARC were used to develop the following equation to predict marbling score:

Table 1. Breed estimates of parameters used to calculate back fat thickness (CB), kidney, pelvic, and heart fat percentage (CK), and surface area of the longissimus muscle (CR)

| Biological type[a] | CB | CK | CR |
|---|---|---|---|
| Hereford | .00236 | .15560 | 1.90109 |
| Angus | .00234 | .18643 | 1.99366 |
| Hereford × Angus | .00247 | .17451 | 1.95660 |
| Jersey × | .00180 | .26997 | 1.95821 |
| South Devon × | .00201 | .21710 | 1.96788 |
| Limousin × | .00221 | .21556 | 2.09158 |
| Charolais × | .00204 | .21457 | 1.99864 |
| Simmental × | .00204 | .21557 | 1.95157 |
| Red Poll × | .00196 | .23311 | 2.00856 |
| Brown Swiss × | .00182 | .19926 | 2.01102 |
| Gelbvieh × | .00173 | .22350 | 2.03719 |
| Maine Anjou × | .00178 | .20841 | 2.03431 |
| Chianina × | .00194 | .21157 | 2.03401 |
| Brahman × | .00258 | .20012 | 1.87958 |
| Sahiwal × | .00250 | .18851 | 1.94861 |
| Pinzgauer × | .00224 | .21522 | 1.98760 |
| Tarentaise × | .00210 | .23782 | 1.95190 |

[a] Jersey × = ½ (Jersey × Hereford + Jersey × Angus), etc.

$$\text{Marbling score} = a \times CFP^{.98}$$

where a is genotypic parameter that is associated with breed differences in marbling score (Williams et al., 1995a) and CFP was obtained from Eq. [9].

*Estimation of Proportions and Weights of Carcasses in Each Quality and Yield Grade Class.* Toward the end of the finishing phase in the feedlot, a trivariate distribution of carcass weight, yield grade, and marbling score was used to determine proportions and weights of carcasses in each yield and quality grade class. The distribution for marbling score was developed from the first three cycles of the GPE program (Cundiff et al., 1986). The calculated distribution for marbling score (Williams et al., 1995a) retained the skewness, kurtosis, and dependence on mean marbling score observed in the data. Table 2 taken from Bennett and Williams (1994) shows expected changes in the distributions of yield and quality grades at three mean carcass weights for a particular genotype. At increasingly heavier mean carcass weights, quality grade increases and yield grade decreases. Also, the mean carcass weights in each yield and quality grade class increase as carcass weight increases. Changes in ACVAL result from the combination of changing proportion of carcasses in each yield and quality grade class as well as increasing carcass weights in each class.

*Market Price Structure and Carcass Pricing Scenarios.* The final piece of information needed to calculate ACVAL is price/kilogram of carcass in each

Table 2. Proportions and average carcass weights (CW) by yield and quality grades averaged across genotypes in the first three cycles of the Germ Plasm Evaluation project at 270, 300, and 330 kilograms average carcass weights

| | | Average carcass weights[a] | | | | | |
|---|---|---|---|---|---|---|---|
| | | 270 | | 300 | | 330 | |
| Yield grade | Quality grade | % | CW | % | CW | % | CW |
| 1 | Choice | 1 | 250 | — | — | — | — |
| 1 | Select | 3 | 244 | 1 | 265 | — | — |
| 1 | Standard | 1 | 239 | — | — | — | — |
| 2 | Choice | 16 | 265 | 10 | 287 | 4 | 309 |
| 2 | Select | 18 | 259 | 8 | 280 | 2 | 302 |
| 2 | Standard | 5 | 254 | 2 | 276 | 1 | 296 |
| 3 | Prime | 1 | 294 | 1 | 315 | 1 | 337 |
| 3 | Choice | 26 | 279 | 35 | 301 | 30 | 323 |
| 3 | Select | 16 | 273 | 15 | 294 | 9 | 316 |
| 3 | Standard | 3 | 268 | 2 | 289 | 2 | 311 |
| 4 | Prime | 1 | 308 | 2 | 330 | 4 | 351 |
| 4 | Choice | 7 | 294 | 18 | 315 | 33 | 337 |
| 4 | Select | 2 | 287 | 4 | 309 | 5 | 330 |
| 4 | Standard | — | — | — | — | 1 | 325 |
| 5 | Prime | — | — | 1 | 345 | 2 | 367 |
| 5 | Choice | — | — | 1 | 330 | 6 | 352 |

[a]Changes in means determined from Koch et al. (1982). Yield grades of 3.10, 3.56, and 4.02 and marbling scores of 9.97, 11.23, and 12.49 are assumed for average weights of 270, 300, and 330 kg, respectively.

quality and yield grade class. In the past, price differences for cattle were largely based on quality grade and dressing percentage. Moves toward value-based pricing have put more emphasis on yield grade. In the present market price structure, no incentive is paid for producing Prime or Choice carcasses, but Select and Standard carcasses are discounted relative to Choice carcasses. Superior cutability (lean yield) as determined by yield grade also has economic value, but generally the value advantage of yield grades better than 3 are not reflected back to the producer, and the market discounts yield grade 4 and 5 carcasses (Preston, 1991). Carcasses that are too light or too heavy are also usually discounted.

Four carcass pricing scenarios described by Bennett and Williams (1994) were used in simulation runs (Table 3). In these scenarios a Choice yield grade 3 carcass is given a weighting of 1, and weightings greater and less than 1 represent premiums and discounts, respectively, within a particular yield and quality grade class. In scenario 1, a premium is paid for Prime carcasses and Select and Standard carcasses are discounted, but yield grade has no effect on price. In scenario 4, premiums are paid for yield grade 1 and 2 carcasses, and yield grade 4 and 5 carcasses are discounted, but quality grade has no effect on price. Scenario 2 is similar to 1, except that yield grade 4 and 5 carcasses are discounted by the same amount. Scenario 3 is a combination of 1 and 4, in that the weighting given to each yield and quality grade class is the sum of the premiums or discounts in scenarios 1 and 4. These pricing scenarios are intended to be representative of past, present, and potential future pricing policies. A price of \$2.73/kg was used for a Choice yield grade 3 carcass, and this price was multiplied by the weightings in Table 3 to obtain carcass price in each quality by yield grade class for each pricing scenario. Carcasses with weights higher than 430 kg and less than 250 kg were discounted by \$10.00/45.4 kg.

### *Estimation of Daily Variable Cost*

Daily variable cost (**VC**) was divided into the following three categories: 1) feed cost, 2) yardage cost, and 3) interest charges on start-up cost and accumulated feed cost.

*Feed Cost.* Feed cost was computed from daily intake of metabolizable energy (**dMEI**), which was predicted with regression equations of MEI on linear and quadratic terms for days on feed (Smith et al., 1976; Cundiff et al., 1981, 1984). During the finishing phase ad libitum access to a diet containing 60% corn silage, 33% concentrate, and 7% supplement on a dry matter basis was simulated for all steers. This represents an average finishing diet for Cycles I, II, and III of the GPE program (Smith et al., 1976). The ME density of this diet was 2.84 Mcal of ME/kg of DM, and 100 kg of DM of the diet contained 182 kg of corn silage (33% DM), 37 kg of concentrate (89% DM), and 8 kg of supplement (89% DM). Corn silage was priced at \$20.95/1,000 kg (Selley, 1992), concentrate was priced at \$92.49/1,000 kg, and supplement was priced at \$220.00/1,000 kg. Cost of 100 kg of DM of this diet was $(182 \times \$.02095) + (37 \times \$.09249) + (8 \times \$.22) = \$9.00$, and cost/Mcal of ME = \$.09/2.84 =

Table 3. Discount and premium pricing scenarios used in simulation runs relative to a Choice, yield grade 3 carcass[a]

| | Yield grade | | | | |
|---|---|---|---|---|---|
| Quality grade | 1 | 2 | 3 | 4 | 5 |
| | Pricing scenario 1 | | | | |
| Prime | 1.05 | 1.05 | 1.05 | 1.05 | 1.05 |
| Choice | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Select | .95 | .95 | .95 | .95 | .95 |
| Standard | .85 | .85 | .85 | .85 | .85 |
| | Pricing scenario 2 | | | | |
| Prime | 1.05 | 1.05 | 1.05 | .95 | .95 |
| Choice | 1.00 | 1.00 | 1.00 | .90 | .90 |
| Select | .95 | .95 | .95 | .85 | .85 |
| Standard | .85 | .85 | .85 | .75 | .75 |
| | Pricing scenario 3 | | | | |
| Prime | 1.15 | 1.10 | 1.05 | 1.00 | .95 |
| Choice | 1.10 | 1.05 | 1.00 | .95 | .90 |
| Select | 1.05 | 1.00 | .95 | .90 | .85 |
| Standard | .95 | .90 | .85 | .80 | .75 |
| | Pricing scenario 4 | | | | |
| Prime | 1.10 | 1.05 | 1.00 | .95 | .90 |
| Choice | 1.10 | 1.05 | 1.00 | .95 | .90 |
| Select | 1.10 | 1.05 | 1.00 | .95 | .90 |
| Standard | 1.10 | 1.05 | 1.00 | .95 | .90 |

[a]Carcass price for any quality by yield grade class within any scenario is computed by multiplying the market price/kilogram of a Choice yield grade 3 carcass by the factor in that quality by yield grade class.

\$.0317. Daily feed cost was computed as dMEI × \$.0317.

*Yardage Cost*. Yardage cost includes cost of labor, cash cost on buildings and equipment, and overhead and management. Custom feeders charge \$.30 per steer per day for yardage (Bryan Melton, personal communication), and it was assumed that if feeders owned the cattle then they should get a return of at least \$.30/d to cover yardage cost; hence, this cost was set at \$.30/d in the simulations. Yardage is considered a separate cost in this study and is not included in feed costs.

*Interest Charges on Start-Up Cost and Accumulated Feed Cost*. Start-up cost was composed of 1) purchase of weaned calf at \$1.94/kg, 2) veterinary and medicine, \$6.85 (Selley, 1992), and 3) miscellaneous, \$6.80 (Selley, 1992). Operating capital used to finance start-up cost and accumulated feed cost was charged interest on a daily basis at a rate of 8% per annum.

### *Sensitivity Analysis*

Changes in optimum carcass weight result from changes in the rate of increase in average carcass value and changes in daily variable cost. Separate runs were made to investigate the impact of changes in the variables affecting average carcass value and daily variable cost on optimum carcass weight. These runs were 1) 10% increase in feed cost, 2) 10% decrease in the base price of a Choice yield grade 3 carcass, 3) 10% increase in purchase price of feeder steers, and 4) increasing the low carcass weight discount point from 250 to 272 kg and decreasing the high carcass weight discount point from 430 to 408 kg. These four items affect profitability of the breeds differently, whereas other costs such as yardage and interest charges would have the same impact on profitability across breeds.

## Results and Discussion

Average profit/steer and percentages of carcasses grading Choice, yield grade 3 or better, with four carcass pricing scenarios, for 17 biological types of steers, at a slaughter end point at which present value of profit/rotation is maximized, are shown in Table 4. Compared with scenario 1, average profit/steer in scenario 3 was not much different for straightbred Hereford, Angus, crossbred South Devon, Simmental, Brown Swiss, Gelbvieh, Pinzgauer, and Tarentaise steers, was greater for crossbred Limousin, Charolais, Maine Anjou, and Chianina steers, and was smaller for Hereford-Angus, Jersey, Red Poll, Brahman, and Sahiwal crossbred steers. For these three groups of steers the percentage of yield grades 1, 2, and 3 carcasses ranked intermediate, high, and low, respectively. In scenario 3 premiums were paid for yield grades 1 and 2, and this would result in higher average profit/steer compared to scenario 1 for breeds

Table 4. Percentages of carcasses grading Choice yield grade 3 or better and average breed profit per steer marketed for 17 biological types of steers and four carcass pricing scenarios at a slaughter endpoint where present value of profit per rotation is maximized, with a base set of input and output prices[a]

| | Average profit/steer | | | | Choice yield grade 3 or better, % | | | |
|---|---|---|---|---|---|---|---|---|
| Biological type[b] | 1[c] | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| Hereford | 18.2 | −.5 | 18.3 | 50.4 | 28 | 28 | 28 | 28 |
| Angus | 35.4 | 13.5 | 31.6 | 39.5 | 53 | 57 | 57 | 57 |
| Hereford-Angus × | 29.7 | .8 | 18.9 | 37.3 | 35 | 39 | 39 | 40 |
| Jersey × | 8.9 | −28.2 | −10.3 | −7.0 | 37 | 48 | 46 | 48 |
| South Devon × | 40.5 | 22.1 | 42.1 | 60.5 | 46 | 48 | 48 | 48 |
| Limousin × | 23.2 | 19.4 | 53.6 | 96.7 | 30 | 29 | 29 | 28 |
| Charolais × | 54.2 | 48.4 | 79.0 | 105.8 | 49 | 48 | 48 | 47 |
| Simmental × | 45.1 | 25.3 | 47.7 | 72.6 | 43 | 44 | 44 | 44 |
| Red Poll × | −4.2 | −28.3 | −9.9 | 7.6 | 40 | 44 | 44 | 45 |
| Brown Swiss × | 60.2 | 38.4 | 61.8 | 82.5 | 47 | 51 | 52 | 51 |
| Gelbvieh × | 68.4 | 46.3 | 70.1 | 97.7 | 41 | 43 | 43 | 42 |
| Maine Anjou | 67.3 | 59.4 | 90.7 | 119.1 | 49 | 48 | 48 | 47 |
| Chianina × | 35.6 | 38.2 | 62.6 | 108.2 | 35 | 34 | 32 | 30 |
| Brahman × | 20.0 | −15.3 | 4.2 | 41.1 | 17 | 21 | 21 | 21 |
| Sahiwal × | 9.9 | −31.4 | −12.5 | 15.3 | 16 | 29 | 29 | 30 |
| Pinzgauer × | 33.6 | 13.4 | 32.9 | 50.1 | 46 | 48 | 48 | 48 |
| Tarentaise × | 38.4 | 14.4 | 34.3 | 60.7 | 34 | 36 | 36 | 36 |

[a]Input prices were 1) feed = \$.0317/Mcal ME, 2) weaned steer = \$1.94/kg, and 3) yardage \$.30/d. Output price was \$2.73/kg for a Choice yield grade 3 carcass.
[b]Hereford-Angus × = Hereford-Angus and reciprocal crosses, Jersey × = ½ × (Jersey × Hereford + Jersey × Angus), etc.
[c]Pricing scenario (see Table 3).

with a high percentage of carcasses with yield grades 1 and 2.

Differences in average profit/steer between genotypes were greater in scenario 4 in which yield grade alone determined carcass value, compared with scenario 1 in which quality grade alone determined carcass value. In this case the increase in value in scenario 4 over scenario 1 was much greater for the leaner genotypes. In separate simulations, average profit/steer was obtained for each genotype within carcass pricing scenario, at a slaughter end point at which profit/day was maximized (Eq. [6]). Average profit/steer with this profit maximizing goal was regressed on linear and quadratic average profit/steer (Table 4), which was obtained at a slaughter end point at which profit/rotation was maximized (Eq. [5]). This regression was forced through the origin (under both profit maximizing goals, profit/day is zero when profit/rotation is zero), and the following relationship was obtained:

$$\text{average profit/steer} = 1.0064 \times X - .0008 \times X^2 \quad (R^2 = 1.00).$$

This result is consistent with the economic theory, in that under profitable market conditions some amount of profit/steer is sacrificed in order to maximize future profits, when the producer's goal is to maximize profit/day.

Except for crossbred Jersey and Sahiwal steers, there were only small differences in the percentage of carcasses grading Choice yield grade 3 or better between the four pricing scenarios. For crossbred Jersey and Sahiwal steers, this percentage was similar in scenarios 2, 3, and 4 but much smaller in scenario 1, in which carcasses were heavier and more of the carcasses were yield grades 4 and 5. There were large breed differences in percentage of carcasses grading Choice yield grade 3 or better. This percentage was smallest in straightbred Hereford and crossbred Limousin, Chianina, Brahman, and Sahiwal steers and greatest in straightbred Angus steers. These breed differences are probably related to breed differences in marbling. At the same percentage of carcass fatness, Angus steers tend to have a greater degree of marbling than straightbred Hereford and crossbred Limousin, Chianina, Brahman, and Sahiwal steers.

Carcass weights at slaughter end points at which the present value of profit/rotation and profit/day are maximized with four carcass pricing scenarios are shown in Table 5 (for 17 biological types of steers). Carcass weights were lightest in scenario 4, for which value was determined on yield grade alone, intermediate in scenarios 2 and 3, for which both quality and yield grade determined value, and heaviest in scenario 1, in which value was determined by quality grade alone. These results suggest that payment on yield grade alone (scenario 4) would result in leaner and lighter carcasses than payment on quality grade alone, or combinations of both quality and yield grade when marketing decisions are based on profit maximization.

Table 5. Average carcass weights in kilograms for 17 biological types of steers and four carcass pricing scenarios at slaughter end points where present value of profit/rotation and profit/day are maximized, with a base set of input and output prices[a]

| | Slaughter end points | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Maximum profit/rotation | | | | Maximum profit/day | | | |
| Biological type[b] | 1[c] | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| Hereford | 305 | 293 | 293 | 289 | 302 | 293 | 289 | 279 |
| Angus | 303 | 290 | 290 | 286 | 296 | 288 | 284 | 278 |
| Hereford-Angus × | 312 | 293 | 295 | 290 | 305 | 293 | 291 | 283 |
| Jersey × | 304 | 282 | 285 | 281 | 302 | 287 | 287 | 283 |
| South Devon × | 321 | 307 | 307 | 302 | 311 | 303 | 297 | 288 |
| Limousin × | 324 | 320 | 316 | 312 | 318 | 316 | 303 | 289 |
| Charolais × | 332 | 327 | 324 | 320 | 318 | 315 | 304 | 293 |
| Simmental × | 358 | 335 | 332 | 323 | 345 | 329 | 317 | 301 |
| Red Poll × | 319 | 295 | 295 | 289 | 320 | 300 | 297 | 287 |
| Brown Swiss × | 373 | 347 | 341 | 328 | 360 | 338 | 321 | 303 |
| Gelbvieh × | 383 | 362 | 358 | 346 | 371 | 352 | 335 | 310 |
| Maine Anjou × | 365 | 357 | 351 | 345 | 346 | 340 | 320 | 304 |
| Chianina × | 378 | 369 | 360 | 348 | 370 | 363 | 339 | 310 |
| Brahman × | 350 | 315 | 319 | 312 | 343 | 320 | 318 | 300 |
| Sahiwal × | 358 | 308 | 311 | 300 | 355 | 315 | 315 | 296 |
| Pinzgauer × | 322 | 306 | 306 | 301 | 314 | 303 | 298 | 289 |
| Tarentaise × | 339 | 316 | 316 | 310 | 328 | 313 | 307 | 294 |

[a]Input prices were 1) feed = \$.0317/Mcal of ME, 2) weaned steer = \$1.94/kg, and 3) yardage \$.30/d. Output price was \$2.73/kg for a Choice yield grade 3 carcass.
[b]Hereford-Angus × = Hereford-Angus and reciprocal crosses, Jersey × = ½ × (Jersey × Hereford + Jersey × Angus), etc.
[c]Pricing scenario (see Table 3).

Differences in optimum carcass weights between the two profit maximizing goals were related to profit/steer at a slaughter end point at which profit/rotation is maximized (Table 4). When profit/steer in a single rotation was close to zero, optimum carcass weights were approximately the same (straightbred Hereford and Hereford-Angus crossbred steers in scenario 2, and crossbred Red Poll steers in scenario 1). As profit/steer increased, optimum carcass weights decreased under the maximum profit/day goal relative to the maximum profit/rotation goal, and the opposite was true as loss/steer increased. In theory, these results show that as profitability increases length of rotation is decreased and steers are marketed at lighter carcass weights when the producer's goal is maximum profit/day compared with maximum profit/rotation. Future expectations of high profit are uncertain and producers would probably modify marketing decisions on the basis of the amount of risk they are willing to accept.

Days on feed in the finishing phase are shown in Table 6 for slaughter end points at which the present value of profit/rotation and profit/day are maximized with four carcass pricing scenarios. Duration of the finishing phase is directly related to carcass weights in Table 5. At similar carcass weights, breed differences in days on feed result from breed differences in postweaning growth rates. Compared with a commercial finishing operation, the long duration of the finishing phase in Table 6 is a result of a lower energy concentration in diet fed to steers in the GPE program.

Breed profit product-moment correlations between the two profit maximizing goals within pricing scenarios (Table 7) suggest that rankings based on breed profits would change very little when the producer's goal was maximum profit/rotation vs maximum profit/day. Breed profit product-moment correlations between pricing scenarios within profit maximizing goals suggest that rankings based on breed profits may be different when value is determined by quality grade alone (scenario 1) compared with when yield grade alone determines value (scenario 4).

### *Sensitivity Analysis*

Absolute changes in optimum carcass weights under different market input/output prices relative to a base set input/output prices (Table 5) within each profit maximizing goal are shown in Table 8. For a 10% increase in feed cost, optimum carcass weights decreased under both profit maximizing goals but decreased more when profit/rotation was maximized. This suggests that changes in variable costs have less impact on optimum slaughter weight when the producer's goal is to maximize profit/day compared with maximizing profit/rotation. Increased purchase price for feeder steers resulted in very little change in optimum carcass weights when profit/rotation was maximized and heavier carcass weights when profit/day was maximized. Feeder purchase price is not included in Eq. [2] and it has only a small impact on maximum profit/rotation through operating interest costs. When the producer's goal is maximum profit/

Table 6. Days on feed in the finishing phase for 17 biological types of steers and four carcass pricing scenarios at slaughter end points where present value of profit/rotation and profit/day are maximized, with a base set of input and output prices[a]

| | Slaughter end points | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Maximum profit/rotation | | | | Maximum profit/day | | | |
| Biological type[b] | 1[c] | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| Hereford | 276 | 253 | 252 | 245 | 271 | 254 | 246 | 228 |
| Angus | 267 | 239 | 240 | 234 | 252 | 235 | 228 | 218 |
| Hereford-Angus × | 263 | 228 | 231 | 223 | 251 | 229 | 225 | 210 |
| Jersey × | 285 | 243 | 250 | 242 | 281 | 254 | 254 | 246 |
| South Devon × | 263 | 239 | 238 | 230 | 246 | 232 | 222 | 208 |
| Limousin × | 271 | 265 | 257 | 250 | 260 | 256 | 234 | 210 |
| Charolais × | 252 | 244 | 238 | 233 | 227 | 223 | 205 | 189 |
| Simmental × | 302 | 265 | 260 | 246 | 279 | 255 | 237 | 215 |
| Red Poll × | 305 | 265 | 265 | 255 | 307 | 274 | 269 | 253 |
| Brown Swiss × | 333 | 293 | 283 | 265 | 311 | 279 | 254 | 229 |
| Gelbvieh × | 339 | 307 | 301 | 284 | 320 | 291 | 266 | 233 |
| Maine Anjou × | 308 | 295 | 285 | 276 | 275 | 266 | 238 | 215 |
| Chianina × | 338 | 325 | 309 | 293 | 326 | 315 | 278 | 236 |
| Brahman × | 306 | 244 | 250 | 240 | 292 | 252 | 248 | 219 |
| Sahiwal × | 364 | 271 | 277 | 258 | 355 | 284 | 283 | 251 |
| Pinzgauer × | 270 | 241 | 239 | 232 | 254 | 236 | 226 | 212 |
| Tarentaise × | 295 | 252 | 251 | 240 | 271 | 245 | 234 | 212 |

[a]Input prices were 1) feed = $.0317/Mcal of ME, 2) weaned steer = $1.94/kg, and 3) yardage $.30/d. Output price was $2.73/kg for a Choice yield grade 3 carcass.
[b]Hereford-Angus × = Hereford-Angus and reciprocal crosses, Jersey × = ½ × (Jersey × Hereford + Jersey × Angus), etc.
[c]Pricing scenario (see Table 3).

day, increased purchase price of feeder steers would reduce the left-hand side of Eq. [3], and this would result in more days on feed and heavier carcass weights.

A 10% decrease in carcass price reduced profit and resulted in decreased optimum carcass weights when profit/rotation was maximized and increased optimum carcass weights when profit/day was maximized. As profitability is reduced, the optimum rotation length is shorter and carcass weight lighter when profit/rotation is maximized, and the opposite occurs when profit/day is maximized. Reducing the range of acceptable carcass weights (carcass weights that are not discounted for being too light or heavy) resulted in a decrease in the optimum carcass weight of Brown Swiss, Gelbvieh, Maine Anjou, and Chianina crossbred

Table 7. Breed profit product-moment correlations for four carcass pricing scenarios at slaughter end points where present value of profit/rotation and profit/day are maximized, with a base set of input and output prices[a]

| | Slaughter end points | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Maximum profit/rotation | | | | Maximum profit/day | | | |
| Item | 1[b] | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| Maximum profit/rotation | | | | | | | | |
| 1 | 1 | .94 | .90 | .80 | .97 | .92 | .87 | .78 |
| 2 | | 1 | .99 | .92 | .94 | .99 | .98 | .92 |
| 3 | | | 1 | .96 | .90 | .98 | .99 | .95 |
| 4 | | | | 1 | .78 | .91 | .94 | .98 |
| Maximum profit/day | | | | | | | | |
| 1 | | | | | 1 | .95 | .91 | .80 |
| 2 | | | | | | 1 | .99 | .93 |
| 3 | | | | | | | 1 | .96 |
| 4 | | | | | | | | 1 |

[a]Input prices were 1) feed = $.0317/Mcal of ME, 2) weaned steer = $1.94/kg, and 3) yardage = $.30 d. Output price was $2.73/kg for a Choice yield grade 3 carcass.
[b]Pricing scenario (see Table 3).

Table 8. Absolute changes in average carcass weights[a] (kg) for 17 biological types of steers in response to a 10% increase in feed or feeder purchase price, or a 10% decrease in carcass price, or a reduction in the range of acceptable carcass weights[b] at slaughter end points where present value of profit/rotation and profit/day are maximized

| | Slaughter end points | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Maximum profit/rotation | | | | Maximum profit/day | | | |
| Biological type[c] | Feed cost | Feeder price | Carcass price | Carcass weight | Feed cost | Feeder price | Carcass price | Carcass weight |
| Hereford | −4 | 0 | −6 | 8 | 0 | 7 | 7 | 9 |
| Angus | −5 | −1 | −6 | 7 | −2 | 6 | 7 | 9 |
| Hereford-Angus × | −5 | 0 | −6 | 8 | −1 | 8 | 8 | 9 |
| Jersey × | −5 | −1 | −7 | 9 | −1 | 9 | 10 | 13 |
| South Devon × | −5 | 0 | −7 | 7 | −1 | 9 | 9 | 8 |
| Limousin × | −6 | 0 | −9 | 4 | −2 | 10 | 10 | 5 |
| Charolais × | −6 | 0 | −10 | 3 | −1 | 11 | 12 | 7 |
| Simmental × | −8 | −1 | −12 | 1 | −2 | 11 | 11 | 2 |
| Red Poll | −6 | −1 | −8 | 9 | −1 | 8 | 8 | 10 |
| Brown Swiss × | −9 | 0 | −13 | −3 | −2 | 9 | 9 | 0 |
| Gelbvieh × | −8 | −1 | −13 | −8 | −2 | 8 | 8 | −5 |
| Maine Anjou × | −10 | 0 | −16 | −7 | −2 | 12 | 11 | −1 |
| Chianina × | −9 | −1 | −15 | −12 | −2 | 8 | 7 | −10 |
| Brahman × | −6 | 0 | −9 | 7 | −1 | 13 | 14 | 6 |
| Sahiwal × | −6 | −1 | −9 | 8 | 0 | 12 | 13 | 7 |
| Pinzgauer × | −5 | 0 | −7 | 7 | −1 | 9 | 10 | 9 |
| Tarentaise × | −6 | 0 | −9 | 6 | −1 | 10 | 11 | 7 |

[a]Changes in carcass weights are relative to carcass weights in Table 4, under carcass pricing scenario 2.
[b]Range of acceptable carcass weights not discounted were reduced from 250 to 430 kg to 272 to 408 kg.
[c]Hereford-Angus × = Hereford-Angus and reciprocal crosses, Jersey × = ½ × (Jersey × Hereford + Jersey × Angus), etc.

steers and an increase in the optimum carcass weight of the other genotypes. Brown Swiss, Gelbvieh, Maine Anjou, and Chianina crossbred steers had the heaviest carcass weights (Table 5, scenario 2), and these carcass weights were closer than the carcass weights of the other genotypes to maximum acceptable carcass weights; hence, for these genotypes a decrease in the maximum acceptable carcass weight resulted in smaller daily increases in average carcass values and lighter carcass weights. The opposite was true for the other genotypes. Reducing the range of acceptable carcass weights had the overall effect of reducing the variation in optimum carcass weights between genotypes.

Table 9. Product-moment correlations between breed profits obtained with different sets of input/output prices[a] and carcass weight discounts at slaughter end points where present value of profit/rotation and profit/day are maximized

| Item | Base | Feed cost | Feeder price | Carcass price | Carcass weight |
|---|---|---|---|---|---|
| | Maximum profit/rotation | | | | |
| Base | 1 | .99 | .99 | .99 | .99 |
| Feed cost | | 1 | .98 | .99 | .99 |
| Feeder price | | | 1 | .98 | .99 |
| Carcass price | | | | 1 | .98 |
| Carcass weight | | | | | 1 |
| | Maximum profit/day | | | | |
| Base | 1 | .99 | .98 | .99 | .99 |
| Feed cost | | 1 | .97 | .98 | .99 |
| Feeder price | | | 1 | .99 | .98 |
| Carcass price | | | | 1 | .98 |
| Carcass weight | | | | | 1 |

[a]Base feed cost = $.0317/Mcal of ME, feeder price = $1.94/kg, carcass price = $2.73/kg, carcass weights between 250 to 430 kg are not discounted, carcass value was obtained with carcass pricing scenario 2. Feed cost, 10% increase in feed cost; feeder price, 10% increase in feeder price; carcass price, 10% decrease in carcass price; carcass weight, carcass weights between 272 to 408 kg not discounted.

Table 10. Average carcass weights in kilograms and breed profits[a] for 17 biological types of steers with carcass pricing scenario 2[b], for an accelerated and a conventional postweaning production system, at a slaughter end point where present value of profit/rotation is maximized

| | Postweaning production system[d] | | | |
|---|---|---|---|---|
| | Accelerated | | Conventional | |
| Biological type[c] | Carcass weight, kg | Profit/ steer, $ | Carcass weight, kg | Profit/ steer, $ |
| Hereford | 296 | 20.7 | 320 | 29.4 |
| Angus | 297 | 32.7 | 324 | 64.0 |
| Hereford-Angus × | 298 | 17.0 | 326 | 49.6 |
| Jersey × | 301 | −2.3 | 317 | 21.2 |
| South Devon × | 312 | 49.3 | 339 | 76.0 |
| Limousin × | 338 | 69.9 | 351 | 83.4 |
| Charolais × | 346 | 90.6 | 353 | 109.8 |
| Simmental × | 332 | 50.6 | 359 | 82.7 |
| Red Poll × | 294 | −7.3 | 325 | 27.6 |
| Brown Swiss × | 336 | 56.5 | 365 | 94.2 |
| Gelbvieh × | 348 | 61.1 | 377 | 108.3 |
| Maine Anjou × | 359 | 83.1 | 372 | 113.3 |
| Chianina × | 361 | 59.7 | 375 | 91.7 |
| Brahman × | 307 | −1.4 | 343 | 47.8 |
| Sahiwal × | 295 | −13.8 | 324 | 21.0 |
| Pinzgauer × | 304 | 30.6 | 331 | 60.7 |
| Tarentaise × | 309 | 28.0 | 336 | 60.3 |

[a]Feed price used in these simulations was $.04/Mcal of ME; all other prices were the same as those used in Table 4.
[b]See Table 3.
[c]Hereford-Angus × = Hereford-Angus and reciprocal crosses, Jersey × = ½ × (Jersey × Hereford + Jersey × Angus), etc.
[d]Accelerated, weaned calves were started on a high-energy finishing diet at weaning. Conventional, weaned calves were started on a high-energy finishing diet after being restricted in growth to gain .5 kg/d for 200 d.

Product-moment correlations between breed profits obtained with a base set of input/output prices and breed profits obtained with different input/output prices and a reduced acceptable carcass weight range within the two profit maximizing goals are shown in Table 9. These correlations suggest that genotype rankings on the basis of breed profits obtained with one set of input/output prices and carcass discount weight range would change very little with uniform changes in input/output prices and carcass discount weight range.

## *Application*

Growth of the 17 breeds of steers was simulated for two production systems, where the finishing diet consisted of 90% concentrate and 10% roughage, with an energy density of 3.00 Mcal of ME/kg of DM. Cost of this diet was $.04/Mcal of ME, and all other prices and costs were the same as in the base run (Table 4). Production systems simulated were 1) an accelerated system in which steers were put on the finishing diet at weaning and 2) a conventional system in which steers were put on a growing diet at weaning to gain 100 kg BW in 200 d, and at the end of the growing phase steers were put on the finishing diet. Growth rates from Williams et al. (1995a) for similar production systems were used in the accelerated and conventional production systems, and methods described by Williams et al. (1995b) were used to calculate ME intake. Simulated results for carcass pricing Scenario 2 are presented in Table 10.

With the accelerated system, average carcass weights were similar to those obtained in Table 5, with carcass pricing scenario 2, but profit/steer was greater for the 17 genotypes. Greater profit/steer is a result of faster growth rates; thus, steers were marketed in a shorter time, with lower feed costs, compared with slower growth rates used in Table 5. Optimum carcass weights with the conventional system were heavier than those obtained with the accelerated system. Postweaning production systems in which steers are restricted in growth after weaning, then put on a high-energy finishing diet, result in leaner carcasses at the same carcass weight (Carstens et al., 1991) compared with systems in which steers are put on a high-energy finishing diet at weaning.

Profit/steer was greater with the conventional system than with the accelerated system. This result is probably due to a combination of feeder-steer purchase price, heavier and leaner carcasses, and lower feed costs associated with a shorter finishing phase. Purchase price of feeder steers in the conventional system was based on a price of $1.68/kg for a 320-kg steer and $1.94/kg for a 230-kg steer in the accelerated system (Selley, 1992). Purchase price of feeder steers has no impact on the carcass weight at which profit is maximized, because we are maximizing profit/rotation (Eq. [2] and [4]). However, if we were to pay $.05 more per kilogram for a 320-kg steer, this would reduce the profit/steer in the conventional system by $16.00.

The regression of breed profit/steer with carcass pricing scenario 4 in Table 4 on breed profit/steer for the same carcass pricing scenario with the accelerated system in Table 10 had an intercept of −13.19 and a slope of 1.02. These results suggest that if carcass value is determined by yield grade alone, then use of low-energy forage-based rations in the finishing phase would be a little less profitable than high-energy concentrate-based rations. However, with very high grain prices, it is possible that low-energy forage-based rations may be more profitable when carcass value is determined on yield grade alone.

*Summary*

The profit maximizing goals used in this study may be applicable to different types of ownership. Maximum profit/rotation may be more applicable to retained ownership with custom feeding, whereas maximum profit/day may be more applicable to cattle feeders who purchase feeder cattle at weaning or as yearlings to finish in their feedlots. Under retained ownership, maximum profit/rotation may be the best strategy, and for cattle feeders the best strategy may be to maximize profit/day when profits are positive and maximize profit/rotation when profits are negative. Under risk and uncertainty more complicated economic models need to be used to predict a producer's profit maximizing behavior.

Maximum profit/rotation is obtained at a slaughter end point at which daily added carcass value is equal to added cost (Eq. [5]). This condition can be evaluated on a daily basis toward the end of the finishing phase and has potential to provide decision support in marketing fed cattle. Breed differences in profitability obtained in this study may be misleading in an integrated production system (retained ownership). In this case it is possible that high cow/calf production costs may be associated with producing more profitable slaughter-steer genotypes, and this may make the entire system unprofitable.

The economic model used to maximize profit/rotation is the same as that used by Amer et al. (1994a), assuming constant animal numbers and varying feedlot size. However, Amer et al. (1994a) used a biological model that was based on prediction equations described by Fox et al. (1988) and the Canadian carcass pricing and value system. Rankings on breed profit for the accelerated system in Table 10 for steers produced from matings of Charolais, Limousin, and Simmental sires on Hereford and Angus dams were the same as those obtained by Amer et al. (1994a,b). Rankings were different for Hereford, Angus, and Hereford-Angus crossbred steers and steers produced from matings of Chianina, Maine Anjou, and Charolais sires on Hereford and Angus dams.

In the biological model we assumed no breed differences in the relationship between live weight and empty body weight (Williams et al., 1992b) and between empty body weight and carcass weight (Eq. [8]). Breed differences in degree of muscling affect dressing percentage (Kauffman et al., 1976); hence, at the same empty body weight breeds with a high degree of muscling would have a heavier carcass than breeds with a low degree of muscling. These differences would affect the average carcass value and possibly the rate of change in average carcass value at a particular empty body weight. Assuming no change in variable costs, it is possible that an increase in dressing percentage may result in heavier optimum slaughter weights and average profit/steer or profit/day.

Product-moment correlations were obtained between breed profit/steer for carcass pricing scenario 2 in Table 4 and breed means for biological efficiency of empty body weight gain predicted by Williams et al. (1995b) for system 9 with a low rate of gain during the finishing period (growth rate averaged across breeds in the first three cycles of the Germ Plasm Evaluation project was very close to the average growth rate for the low finishing rate of gain). Correlations were .87, .23, and .09 for the 300-kg carcass weight, small or greater degree of marbling, and 28% carcass fat slaughter end points. These results indicate that biological efficiency of empty body weight gain obtained at a minimum (marbling) or a maximum (carcass fat) degree of finish was not related to breed profit/steer at a slaughter end point where profit/rotation was maximum.

A complete FORTRAN computer program and instructions covering the body composition model, carcass quality and yield grade distribution, and marginal analysis are available upon request.

## Implications

Methods were developed to predict slaughter end points at which net present value of profit was maximized for different genotypes of cattle. Results suggest that breed choices may not be affected by changes in input/output market prices but may be different with different carcass grading and value systems and postweaning production systems. Compared with a carcass value system based on quality and yield grade, a system based on yield of lean meat would tend to result in leaner and lighter carcasses. These results are for postweaning phase only and may be different under retained ownership, for which higher costs associated with the cow-calf phase may reduce profitability of the leaner genotypes. The methods developed in this study also have decision support potential in marketing fed cattle.

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